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Photocurrent under carrier tunneling in GaAs/AlGaAs coupled quantum wells embedded in p-i-n heterostructure

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Abstract. Photocurrent-bias characteristics of coupled quantum well photodiode were studied at different intensities of illuminating light with various spectral range. The optimal conditions for observation of THz radiation emission from such device are established.

Emission and absorption of THz frequency radiation in different nanostructures are intensively studied during last years [1–3]. In this paper we report the results of photoelectric investigations of p-i-n heterostructures with embedded coupled quantum wells (CQWs). We hope that the next step will be the observation of THz radiation emission from these structures. The main feature of studied CQW photodiode implies that the energy separation of the lowest two electronic subbands is voltage-tuned in the THz-frequency range.

The experiments were performed on the device consisted of 25 undoped GaAs/ $Al_{0.33}Ga_{0.67}As$ CQW units grown by molecular beam epitaxy in the intrinsic region of a p-i-n diode. The CQW consisted of a narrow well (7.9 nm) and wide well (15.8 nm) separated by a thin barrier (1.7 nm). Adjacent CQWs were separated by a thick barrier (15.3 nm). There are six electronic levels in such CQWs. The states with the energies $E_1 = 15$ meV, $E_3 = 65$ meV, $E_4 = 133$ meV and $E_6 = 242$ meV are generated by the wide well and the states $E_2 = 43$ meV and $E_5 = 179$ meV are connected with the narrow well (these values are calculated for zero bias). For reverse bias up to 7 V the energy separation of the lowest two electronic levels is varied through a range from 10 to 30 meV.

The wafer was selectively etched to produce 400 mm diameter mesa structures. A gold electrical contact with integral grating coupler was deposited onto the surface of the mesa. The experiments were performed at 4.2 K with the sample immersed in liquid helium.

To investigate photocurrent we illuminated the mesa through optical fiber with modulated light of different spectral range and intensity. We used red laser (680 nm), halogen lamp with different optical filters, flash-light lamp. At reverse bias of 1.8 V there was a peak of photocurrent due to resonant tunneling of electrons from 1-st subband of one well to the 2-nd subband of neighbor well. Such resonant tunneling has to be accompanying with emission of THz radiation.

In similar structures the absorption of THz radiation was studied. When the THz photon energy is resonant with the intersubband splitting a direct optical transition is allowed and the absorption of THz photons by carriers is strongly enhanced. Corresponding change of the photocurrent in the device was observed.

In this paper we demonstrate photocurrent-bias characteristics for different conditions of optical pumping. At Fig. 1 the photocurrent-bias characteristics for different intensities

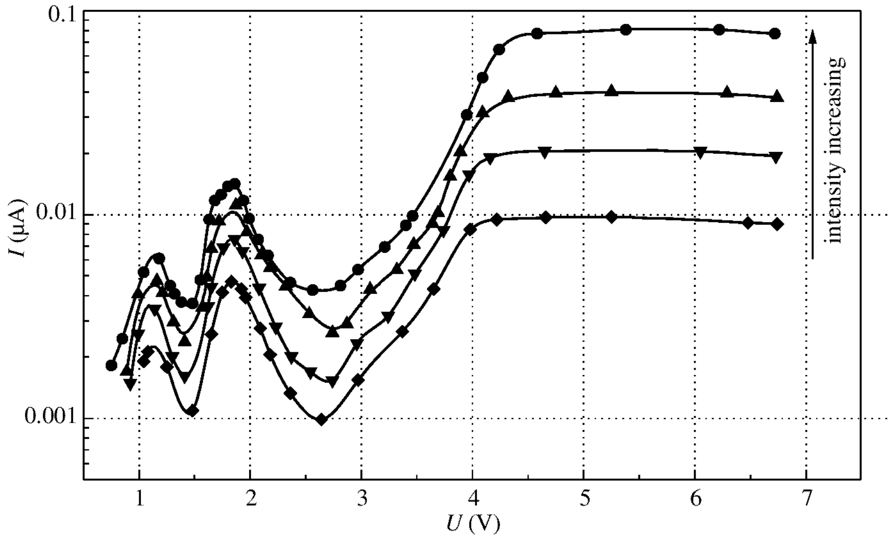

Fig. 1. Photocurrent-bias characteristics of CQW photodiode for different intensities of pumping light (halogen lamp).

of "white" light with the same spectral range are represented. These characteristics and the bias dependence of photocurrent under illumination by light sources with different spectral range are discussed taking into account the energy diagram of CQWs and the possibility of domain formation [4]. Relying on the experimental data we establish the optimum for obtaining THz radiation emission.

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